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**Specifications for iron, manganese and
chromium mineral exploration**

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Specifications for iron, manganese and chromium mineral exploration

1 Scope

This standard specifies the specifications of geological exploration for iron, manganese, chrome minerals, including scope, normative references, objectives and tasks of exploration, degree of investigation and study, requirements for exploration control, exploration work and quality requirements, feasibility evaluation, classifications of mineral resources/reserves, type conditions, requirements for mineral resources/reserve estimates, etc.

This standard is applicable to geological exploration of iron, manganese and chrome ore as well as the mineral resource/reserve estimate. It is also applicable to the inspection and evaluation of exploration reports of iron, manganese, chrome mineral. It may also be used as the basis for evaluating and estimating mineral resources/reserves in such activities as mining rights transfer, financing, fund-raising, stock listing for mineral exploration and development.

2 Normative references

The provisions in following documents become the provisions of this standard through reference in this standard. For the dated references, the subsequent amendments (excluding corrections) or revisions do not apply to this standard; however, parties who reach an agreement based on this standard are encouraged to study if the latest versions of these documents are applicable. For undated references, the latest edition of the referenced document applies.

GB/T 13908-2002 General requirements for solid mineral exploration

3 Purpose & task of exploration

3.1 Pre-review

Through comprehensive study on geology, geophysical exploration, geochemical exploration, remote-sensing in the region, preliminary field observations, a very small number of engineering verification results, comparison with deposits of known similar geological features, propose the

select prospecting areas, to carry out pre-review work. Make evaluation for the geophysical anomalies, geochemical anomalies, remote-sensing anomalies, mineralization points, ore deposits which have ore-forming conditions in the pre-review region, to initially understand their characteristics and distribution ranges, to provide a basis for further general check.

4.1.2 General review stage

Collect such data as geological, mineral, geophysical, geochemical, remote-sensing geology, to understand regional geological features and prospects for mineralization. Roughly identify the strata, lithology, thickness, occurrence, distribution in the reviewed region. Roughly identify the distribution, scale, occurrence of larger folds, faults, fracture zones. Roughly identify the type, quantity, form, distribution of intrusive rocks or eruptive rocks. Evaluate all kinds of geophysical anomalies, geochemical anomalies, remote-sensing anomalies, ore deposits or mineralization points, to roughly identify their output characteristics and distribution range. For mineral deposits (body) with further working value in the region, it shall roughly identify the distribution, quantity, location of occurrence, thickness, scale, occurrence, ore quality. It shall roughly understand the development of the oxidation zone of the deposit (body), to provide basis for further detailed review work.

4.1.3 Detailed review stage

4.1.3.1 Regional geology: Further study such data as the stratum, structure, magmatic rocks, metamorphic rocks, minerals related to mineralization in the region. Based on such data as geophysical, geochemical, remote-sensing geology, clarify the location, regional geological features, mineralization conditions, mineralization prospects of iron, manganese, chromium minerals in regional structures as well as the major minerals in the region.

4.1.3.2 Mining region (bed) geology: Roughly identify the stratigraphic age, sequence, lithology, thickness, occurrence, distribution. For sedimentary deposits and metamorphic deposits, it shall also study the sedimentary environment of ore-bearing strata (rock series), lithofacies, rock combination, metamorphism, the distribution and change rule of ore-forming elements; determine the ore-bearing stratum as well as the spatial distribution of ore bodies in the stratum. Study the relationship between the structure of the mining area and the spatial distribution of ore bodies. Roughly identify the nature, scale, occurrence, mutual relationship, distribution law of the folds, faults, fracture zones which control the ore body. For the large faults which have large displacement and divide the ore body, it shall roughly understand its spatial position, occurrence, displacement. For the small faults, it shall, based on the surface engineering data, preliminarily describe their scope and distribution. Study and basically identify the types, forms, scales, occurrences of intrusive rocks and eruptive rocks. Understand the intrusion (eruption) era, period,

the degree of destructive impact of the structure or the veins on the ore body after the mineralization. For the main ore body of the preliminary mining section, it shall control its form, spatial location, occurrence in detail. For the small ore bodies with industrial value on the main ore body of the preliminary mining area, it shall also be controlled at the same time. If necessary, it may densify the project to improve the degree of exploration and study. For open pit mining, in order to determine the boundary of the open pit, it shall systematically control the boundary around the main ore body and the orebody at the bottom of the open pit; for the underground mining bed, it shall control the both ends, upper and lower boundaries, extension of the main orebody, to determine the location of the development project.

4.2 Study of ore quality

4.2.1 Pre-review stage

Preliminarily understand the mineral composition, chemical composition, main elements of the ore.

4.2.2 General review phase

Roughly identify the ore minerals, gangue minerals, ore grades, structural constructions, natural types of ore. Roughly understand the content and distribution of useful, beneficial, harmful components, to provide basis for determining whether it is industrially applicable.

4.2.3 Detailed review stage

Basically identify the ore minerals, types and contents of gangue mineral, ore structural characteristics. Basically identify the type, content, occurrence state, law of distribution of the useful, beneficial, harmful components. Preliminarily divide the natural types and industrial types of ores; study the law of distribution. Provide a basis for the overall planning of the mining area, the project proposal for the mine construction, the pre-feasibility study.

4.2.4 Exploration stage

Identify the types and contents of ore minerals and gangue minerals in detail. Study the interrelationship and distribution of ore minerals. Identify the content, occurrence state, distribution of useful, beneficial, harmful components in detail. Study the structure and distribution characteristics of ore in detail. Identify the grain size and embedding characteristics of iron, manganese, chromium minerals and major gangue minerals. According to such factors as the mineral composition, content, structure and oxidation degree of the ore, determine the natural types in detail. Determine the boundary of oxidation zone, the mixed zone, the original ore. On the basis of dividing the natural type of ore, according

pre-review, it shall collect the regional hydrogeology, engineering geology, environmental geological data, to provide a basis for further work.

4.4.2 General review stage

On the basis of collecting regional hydrogeology, engineering geology and environmental geological data of the study area, understand the distribution of surface water bodies in the mining area, understand the stability of the surrounding rock and ore of the ore body (stratum) as well as the environmental geological conditions, to provide a basis for further work.

4.4.3 Detailed review stage

4.4.3.1 Hydrogeological study: Based on the understanding of regional hydrogeological conditions and the collection of local hydrological and meteorological data, basically identify the lithology, thickness, distribution, occurrence, burial conditions of the aquifer and water-confining layer, the water-richness of aquifer, the hydraulic connection of each aquifers, the stability of the aquifer and degree of water isolation. Basically identify the surface water distribution in the mining area as well as its hydraulic connection with the main aquifer. Study the groundwater level (water pressure), water quality, water temperature, water quantity, dynamic change and recharge, runoff, discharge conditions; preliminarily determine the mine pit's water filling factors; predict the water inflow of the mine pit. Preliminarily divide the hydrogeological types of deposit; determine the complexity of hydrogeological conditions. Propose the direction of water resources for industrial and domestic use of mine.

4.4.3.2 Engineering geological study: Determine the mechanical properties of the main rock ore in the mining area; study its stability. Basically identify the distribution of fault fracture zone, joints, fissures, weathering belt, mudding belt, sand-flowing layer, weak interlayer in the mining area; evaluate the influence on the stability of the ore body and its surrounding rock strata. Propose the evaluation opinions on the stability of the side slope of open pit. Investigate the distribution, filling and water accumulation of the old cavity and the goaf. Preliminarily determine the engineering geological type of the deposit and determine the complexity of engineering geological conditions.

4.4.3.3 Environmental geological study: Basically identify the composition and content of elements, radioactive and other harmful gases which are harmful to the human body in rocks, ores and groundwater (including hot water). Propose the preliminary evaluation opinions on whether there is any harm to the human body. Collect relevant data on natural geological disasters such as earthquakes, debris flows, landslides, karst, etc.; analyze their impact on mine production. Predict the possible impact of mining on the environment and ecology of the area.

earthquake and new tectonic activity; clarify the seismic geological conditions of the mining area and the stability of the mining area. Evaluate the geological environment quality before the mining of the deposit. Predict the damage and impact on the environment and ecology of the mining area during the mining; propose preventative recommendations.

4.5 Comprehensive evaluation of comprehensive exploration

4.5.1 Pre-review stage

Initially understand whether there are other beneficial minerals.

4.5.2 General review stage

For symbiotic and associated minerals with industrial utilization value, it shall roughly identify their content and occurrence characteristics, study the possibility of comprehensive utilization.

4.5.3 Detailed review stage

For the symbiotic and associated minerals with industrial utilization value, it shall roughly identify the material composition, content, occurrence state, distribution state; determine the possibility of industrial utilization.

4.5.4 Exploration stage

For symbiotic and associated minerals which have industrial utilization value within the exploration area, it shall carry out comprehensive exploration and comprehensive evaluation. Identify the material composition, content, occurrence state, distribution law; determine and evaluate the distribution rate of symbiotic and associated useful components in different minerals. For the associated beneficial components in the ore that are beneficial to improve the quality of the processed products, but cannot be recycled at the time of processing, they shall also be evaluated; however, the reserves are not separately estimated. For symbiotic minerals in the ore body and in the adjacent surrounding rock, it shall make full use of the exploration project to carry out evaluation. If necessary, it shall properly densify the project to improve its control and study level. For the degree of exploration and study on symbiotic minerals, it shall follow the requirements of the geological exploration specification of corresponding ore.

Different types of iron, manganese, chrome deposits may contain different symbiotic (associated) components, some of which, if exceeding a certain limit, will pose a hazard to the smelting products. However, when these components may be separated through processing means, and become useful components through comprehensive recycling use, it shall pay attention to comprehensive

in time.

5.2 Principles for determining the spacing of exploration projects

5.2.1 According to the exploration type and the exploration stage, select the corresponding spacing of exploration engineering.

5.2.2 The engineering spacing at the detailed review stage is the basic engineering spacing for the exploration of the deposit. The engineering spacing during the exploration stage is in principle densified on the basis of the spacing of basic engineering. In the pre-review and general review stages, due to the scarcity of engineering work, it has no specific requirement for the engineering spacing, but it shall make full consideration to the connection with subsequent projects.

5.2.3 The engineering spacing of the type-III exploration in the exploration stage is the densest spacing of the exploration project of deposit. For some deposits with small scales and large variations in form and composition, if it is still difficult to obtain ideal exploration results according to the engineering spacing, it shall be converted into the “mining whilst exploration” method, to make further investigation on the geological characteristics of the occurrence of deposit in the mining process.

5.2.4 When the change of the ore body in the direction of the strike is greater than that in the direction of tendency, the project may be arranged into a rectangular mesh whose short side is in the direction of the ore body.

5.2.5 Mark the surface engineering spacing of the ore body, which is generally one-half of the engineering spacing of the deep part.

5.2.6 Once the exploration type has been revised, the engineering spacing of the exploration shall also be adjusted accordingly.

5.3 Control level of exploration

First of all, it shall control the distribution range and mutual relationship of the ore bodies in the exploration area. The level of specific control shall, according to multiple factors such as the exploration stage, the output characteristics of the deposit and the possible construction scale (including the service life of the mine), the degree of market demand, be agreed with the investors (Appendix D.3).

6.3.2 Carry out the magnetic, gravity, electric measurement at different scales. To identify such information as boundary, shape, occurrence of the rock and ore body, study the structural belt, find hidden ore body, it shall make full use of borehole geophysical exploration method, retrieve the boundary of the ore body, understand the shape and occurrence of ore body.

6.3.3 When surveying magnetic iron ore, it shall use the surface magnetic survey data, to infer and delineate the distribution range, shape, occurrence, depth, thickness change of the ore body as well as the geological structure. Use the borehole three-component magnetic survey, to determine the location through which the borehole penetrates the ore body (layer), to solve the problem of ore body extension and relative connection, to detect the blind ore body aside the borehole and at the bottom of the borehole. Drilling holes in the control section shall ensure that the magnetic curve anomalies in the borehole can pass through the ore body (layer) to enter the normal field, to facilitate correct interpretation.

6.3.4 When surveying weak magnetic or non-magnetic deposits such as hematite, limonite, siderite, rhodochrosite, manganese oxide ore, chrome ore, it shall use experiments and select the high-precision magnetic survey, gravity or electric method, to obtain the information which is beneficial for the understanding and explaining the ore body.

6.3.5 During the exploration and detailed survey stage, carry out radioactive testing of the surface and rock core of the control section. When an abnormality is found, it shall identify the cause and make evaluation.

6.3.6 The quality requirements of geophysical work shall be carried out in accordance with current professional codes and procedures. After the end of the field work, it is necessary to sort out the materials in time, prepare the geophysical maps that are compatible with the scale of the geological map, submit a work summary report. The mineral exploration report shall briefly explain the results of geophysical exploration work, review its quality.

6.4 Prospecting works

6.4.1 Trench prospecting: It is the main project to systematically expose the surface ore body. It is generally used under the condition that the thickness of the overburden does not exceed 3 m. In order to ensure the sampling quality, the trench must be dug to the fresh surface of the bedrock.

6.4.2 Shallow well (drills): When the overburden is thick, it shall use shallow well (drills) to control the shallow part or shallow ore body. Shallow wells (drills) must expose the boundary between the top & bottom plate of the ore body and the surrounding rock or the fresh surface of the bedrock.

sectional specification is generally not less than 20 cm × 15 cm.

6.5.2 Processing of sample

6.5.2.1 Processing requirements: The total loss rate of the sample's mass during the whole process of sample processing shall not exceed 5%. The reduction error of the sample shall not exceed 3%.

6.5.2.2 Step-by-step reduction processing: The preparation of the analytical sample uses the Chechott formula for reduction:

$$Q = Kd^2$$

Where:

Q - The minimum reliable mass of the sample (kg);

k - The reduction factor;

d - The largest particle diameter in the sample (mm).

The K value which is commonly used for iron ore and manganese ore is usually 0.1 ~ 0.2. The chromium ore is generally 0.25 ~ 0.3.

6.5.2.3 Processing of mechanical linkage line: After primary crushing and reduction, it directly achieves the required particle size and mass. It shall be carried out in accordance with the determined processing methods and operating procedures. The shrinkage uniformity of the sample shall be tested.

6.5.3 Analysis

6.5.3.1 Basic analysis: It is mainly used to identify the content of useful components in ore. It is the main basis for delineating ore bodies, classifying ore types, estimating resources/reserves.

- a) The basic analysis items of iron ore: When magnetic iron ore or other types of ore are delineated by the use of magnetic iron content, the analysis item is TFe and mFe; the hematite ore, limonite ore, siderite ore are TFe. The symbiotic minerals in ore shall also be included in the basic analysis;
- b) Basic analysis items of manganese ore: For oxidized ore, analyze Mn, Fe, P, SiO₂; for manganese carbonate ore, it shall also analyze CaO, MgO, Al₂O₃, loss on ignition. For other harmful elements, when its content is high and affects the quality evaluation of ore, they shall also be subjected to basic analysis;
- c) Basic analysis items of chrome ore: Cr₂O₃, FeO, Fe₂O₃; depending on the

requirements.

6.5.3.7 Mass inspection of chemical analysis: It mainly check the accidental error and systematic error of the basic analysis. It shall also check it in the phase analysis.

- a) Internal inspection: The internal inspection samples shall be taken by the sample delivery organization in time and in batches from the basic analysis sub-samples, encoded, sent to the original laboratory for inspection. The amount of the internal inspection sample is respectively 10% of the basic analysis amount and 3% ~ 5% of the combined analysis amount. When the sample amount is less, the internal inspection for the basic analysis samples shall be not less than 30; the internal inspection for the combined analysis samples shall be not less than 10;
- b) External inspection: The external inspection samples shall be taken by the sample delivery organization in periods and in batches from the basic analysis samples, then sent by the basic analysis laboratory to the designated laboratory for inspection. The amount of the external inspection sample is respectively 5% of the basic analysis amount and the combined analysis amount. When the basic analysis sample amount is less, the amount of external inspection samples shall be not less than 30;
- c) Chemical analysis mass and the error of internal-external inspection analysis results are processed with reference to DZ/T 0130 "The specification of testing quality management for geological laboratories".

6.6 Collection, analysis, test of ore processing sample

The processing test index is an important basis for determining the ore processing flow, establishing the industrial index of mineral resources/reserves, evaluating the industrial value of iron, manganese, chrome deposits. For any ore processed, it shall take the processing test samples. According to the "Interim provisions on the degree of processing test at different stages of mineral exploration", combined with the ore processing performance of iron, manganese, chrome ore in China, it requires carry out laboratory process tests in the detailed review stage and the exploration stage. When the ore's composition is complex, it shall also carry out the laboratory extended continuous test, to evaluate the processing performance of the ore.

For taking of processing sample, it shall negotiate with the responsible test organization to prepare the sampling design, solicit opinions from the design-production department of mine. The samples taken shall be fully representative. The ore type, grade, mineral composition, structural construction, chemical composition, spatial distribution of the sample are required to be basically

6.8.1.1 The original geological catalogue is a record of the on-site records and observational study methods for observing the study of geological phenomena, which shall be timely, true, objective.

6.8.1.2 The original geological catalogue includes measured cross-sections, geological mapping, trench prospecting, well prospecting, pit prospecting, drilling engineering, sampling, etc.

6.8.1.3 Records are means which are taken by the original cataloger to select appropriate information, such as numbers, text, images, tapes, disks (CD), etc. It is also necessary to adapt to the construction of the national information system and adopt new methods and means in a timely manner.

6.8.1.4 The original geological catalogue is, based on various measurement results as well as the identification and test results of the specimens and samples, to correct, supplement, sort the on-site catalogue, to prepare necessary charts, to use specified format for finishing. When using the computer for original cataloging, it shall also save and store the original data in the specified format in time.

6.8.1.5 The original geological catalogue shall be inspected and accepted. Those which are not accepted or unqualified after inspection shall not be used.

6.8.2 Comprehensive sorting of data

6.8.2.1 Comprehensive sorting of geological data is an important part of geological exploration work, which shall be throughout the geological exploration work.

6.8.2.2 Comprehensive sorting of data includes the compilation of geological mapping data, prospecting engineering data, hydrogeological engineering geological data, chemical sample analysis and test results, test results of physical-technical performance of rock ore, geophysical exploration data, survey data, etc., as well as the compilation of comprehensive chart and estimate of mineral resources/reserves.

6.8.2.3 The sorting results of comprehensive data shall be subject to quality inspection and acceptance.

6.8.2.4 In order to improve the sorting level of comprehensive data, the data, charts, maps, etc. shall actively use computer technology for data processing and production.

6.8.3 Preparation of exploration report

For each exploration stage, it shall prepare corresponding exploration reports. According to the nature of the report carrier, the report may be divided into two

reference industrial indicators after detailed review or exploration, the laboratory-scale processing test data, the cost as estimated through the comparison of data as obtained from price list or similar mine development.

7.3 Feasibility study

It refers to the detailed evaluation of the economic significance of the development of the deposit. The results can be used to evaluate the technical-economic reliability of the proposed project in detail. It may be used as the basis for decision-making on investment. The cost data used is highly accurate, which is usually based on the reserves as obtained by exploration and the corresponding test results of processing performance. The various parameters as required for the cost and equipment quotation are the current market price, which also makes full consideration of the impacts of various factors such as the geology, engineering, environment, law, government economic policies, so they are highly time-sensitive.

8 Classification and type conditions of mineral resources/reserve

8.1 Basis for classification of mineral resources/reserves

8.1.1 Geological reliability

8.1.1.1 Predicted: It refers to the results of pre-review of areas with large mineralization potential. Only when there is preliminary data and it can be compared with the known deposit which has similar geological characteristics, the predicted resource amount can be estimated.

8.1.1.2 Inferred: It refers to, for the general review area, based on the accuracy of the general review, roughly identify the geological characteristics of the mineral and the distribution characteristics, grade, quality of the ore body (point). It also includes the extrapolated part of the basic reserves or resources which have higher geological reliability. The continuity of the ore body is inferred. The data based on which the mineral resource is estimated is limited, so the credibility is low.

8.1.1.3 Controlled: It refers to, within a certain range of the mining area, according to the accuracy of detailed review, the rough identification of the main geological characteristics of the deposit, the shape of the ore body, the occurrence, the scale, the quality of the ore, the grade, the technical conditions of the mining. The continuity of ore body is basically determined. The data

ore body; identifying in detail the geological characteristics of the deposit, the ore quality and mining technical conditions; there is corresponding ore processing test results; it has been made feasibility study, including the study and corresponding correction of the mining, processing, economy, market, law, environment, social, government factors, to prove that the mining is economic at the time of calculation. The estimated recoverable reserve and the feasibility evaluation results are highly reliable.

8.2.1.2 Pre-recoverable reserves (121): It is the recoverable part of the proven economic base reserves. It refers to, in the section of the densified project which reaches the exploration stage, delineating in detail the ore body in three-dimension space; confirming the continuity of the ore body; identifying in detail the geological characteristics of the deposit, the quality of ore, the technical conditions of mining; meanwhile there is corresponding ore processing test result. However, only the pre-feasibility study is carried out to prove that the mining is economic at that time. The estimated recoverable reserve is highly credible, whilst the credibility of the results of feasibility evaluation is ordinary.

8.2.1.3 Pre-recoverable reserves (122): It is the recoverable part of the controlled economic base reserves. It refers to, in the section which reaches the work degree in the detailed review stage, delineating basically the three-dimension form of the ore body; confirming more or less the section where the ore body is continuous; identifying basically the geological characteristics of the deposit, the quality of ore, the technical conditions of mining, the achievements of the test of the processing performance of the ore provided. For easy-to-process ore with mature processes, it may also make use of the test results of the ore of the same types. The results of the pre-feasibility study indicate that the mining is economic. The estimated recoverable reserves are highly reliable. The credibility of the feasibility evaluation results is ordinary.

8.2.2 Basic reserves

8.2.2.1 Proved (feasibility study) economic base reserves (111b): It refers to the recoverable reserves without deduction of design and mining losses (111).

8.2.2.2 Proved (pre-feasibility study) economic base reserves (121b): It refers to the pre-recoverable reserves without deduction of design and mining losses (121).

8.2.2.3 Controlled economic base reserves (122b): It refers to the pre-recoverable reserves (122) without deduction of design and mining losses.

8.2.2.4 Proved (feasibility study) marginal economic base reserves (2M11): It refers to, in the section which reaches to the requirements of the work degree in the exploration stage, identifying in detail the geological characteristics of the deposit, ore quality, technical conditions of mining; delineating the three-

section where the exploration work had reached the requirements of the detailed review stage, the geological reliability is controlled. The results of the pre-feasibility study indicate that at the time of the determination, the mining is uneconomic. It will become economic after substantially increasing the price of mineral products or significantly reducing the costs. The estimated resource is highly credible. The credibility of the feasibility evaluation results is ordinary.

8.2.3.4 Proved intrinsic economic resources (331): It refers to, in the section where the exploration work had reached the requirements of the exploration stage, the geological reliability is proved. However, except for the rough study, no feasibility study or pre-feasibility study is made. The economic significance is within the scope of the economic to the sub-marginal economic. The estimated resource is highly credible. The credibility of the feasibility evaluation is low.

8.2.3.5 Controlled intrinsic economic resources (332): It refers to, in the section where the exploration work had reached the requirements of the detailed review stage, the geological reliability is controlled. For the feasibility evaluation, it only makes rough study. The economic significance is within the scope of the economic to the sub-marginal economic. The estimated resource is highly credible. The credibility of the feasibility evaluation is low.

8.2.3.6 Inferred intrinsic economic resources (333): It refers to, in the section where the working degree of exploration only reaches to the requirements of the general review stage, the geological reliability is inferred. The resource is estimated only based on limited data, so its reliability is low. For the feasibility evaluation, it only makes rough study. The economic significance is within the scope of the economic to the sub-marginal economic. The credibility of the feasibility evaluation is low.

8.2.3.7 Predicted resources (334)?: Based on results of regional geological study, aviation, remote-sensing, geophysical, geochemical abnormalities or very small amount of engineering data, determine the area with mineralization potential. Meanwhile compare it with the known deposit to estimate the resources. It belongs to potential mineral resources. The economic significance is still uncertain.

9 Estimate of mineral resources/reserves

9.1 Industry index of deposit

The industry index of deposit refers to, under the current technical-economic conditions, the comprehensive criteria of industrial utilization to which the deposit shall reach. It is the basis for evaluating the industrial value of the

deposit, delineating the ore body, estimating the mineral resources/reserve. It is determined based on the policy of protecting and rationally utilizing mineral resources, as well as national economic policies, technical level, economic benefits, and other factors. It consists of two parts: ore quality (chemical or physical) indicators and mining technical conditions of deposit (Appendix E.1.1). In the pre-review stage and the general review stage, it may use the general industrial index of the deposit (Appendix E.1.2). In the detailed review stage and the exploration stage, it shall be based on the geological characteristics of the deposit, combined with the achievements of pre-feasibility study or feasibility study, based on the market price at that time, to carry out demonstration. The investor (owner) provides the geological exploration organization with the mineral industry indicators which are formulated and issued according to the procedures prescribed by the state.

9.2 General principles for estimate of mineral resources/reserves

9.2.1 Depend on the exploration stage, determine the corresponding industry indicators of deposit.

9.2.2 According to the geological characteristics of the ore body's output and the arrangement of the exploration project, reasonably select the estimation method (Appendix E.2). Promote and encourage the use of new technologies and methods. For any estimation method used, it shall select a part of representative ore bodies or block segments shall, use other estimation method for verification and comparison.

9.2.3 The computer software used for estimate must be approved by the competent department of geology and mineral resources under the State Council.

9.2.4 When delineating the ore bodies of symbiotic minerals which have industrial utilization value, it shall consider the spatial and morphological consistency with the main ore body as much as possible. When delineating the range of associated components which have industrial comprehensive utilization value, it must be carried out in accordance with the principle of spatial consistency with the main ore body (ore block or ore segment).

9.2.5 For the mined deposits, it shall deduct the reserves of the goaf at the end of the field work of geological exploration according to the actual data.

Appendix C

(Informative)

Main types of iron, manganese, chrome deposits

C.1 Main types of iron deposits

C.1.1 Late magmatic iron deposit

C.1.1.1 Late magmatic differentiation-type iron deposit

It is produced in basic and ultrabasic igneous rocks such as gabbro-olivine. A single ore-bearing rock mass is intermittently extended for several kilometers to several tens of kilometers and one to several kilometers wide. The ore body is a relatively regular multi-layered bed, produced in the middle and lower part of the rock mass and at the bottom of the cyclothem. The ore body (layer) has a cumulative thickness of tens to two to three hundred meters and a depth of several hundred meters to several kilometers, mostly large deposits. After mineralization, faults and veins develop, which often destroy the continuity of the ore body in the strike and tendency. The ore has a disseminated, strip, lump structure, in a ruthenium-iron intercalation structure and a solid solution decomposition structure. The metal mineral is mainly composed of titanomagnetite ore, the second is granular ilmenite; meanwhile it contains a small amount of pyrrhotite, pyrite and other cobalt-nickel sulfides. The gangue minerals are pyroxene, basic plagioclase, olivine, apatite, and the like. In the ores, generally the $w(\text{TFe})$ is 20% ~ 45%, the $w(\text{TiO}_2)$ is 3% ~ 16%, the $w(\text{V}_2\text{O}_5)$ is 0.15% ~ 0.5%, the $w(\text{Cr}_2\text{O}_3)$ is 0.1% ~ 0.38%, associated with Cu, Co, Ni, Ga, Mn, P, Se, Te, Sc, and platinum group elements. The ore needs to be beneficiated before it can be smelted. Example of a deposit: Panzhihua Iron Mine.

C.1.1.2 Late magmatic penetrating deposit

Produced in gabbro and plagioclase. There is certain fracture distributed in the ore body along the rock mass. Or otherwise it is produced in the contact zone between the gabbro and the plagioclase. The shape of the ore body is irregular, generally in the form of lentils or veins in groups, it is in geese line-up and pitched to deep part. A single ore body has a length of several meters, ranging from tens to hundreds of meters; it has a thickness of several meters to several tens of meters; it has a depth of several tens to hundreds of meters. The size of the deposits is mostly small and medium. The ore is a dense lump, disseminated structure. The useful mineral particles in the ore are coarser, wherein rutile is common without titanite. The ore's mineral composition and

invasive activities vary in size. Large ore bodies are more than a kilometer long, with thicknesses ranging from tens to two to three hundred meters and hundreds to thousands meters wide. The ore body is layered, cake-shaped, lentoid, bell-shaped, ring-shaped, capsule-shaped. The occurrence is almost horizontal, or otherwise dip towards outside at a gentle angle. The ore minerals are mainly magnetite, martite, hematite; it contains pyrite. The gangue minerals are diopside, actinolite, apatite, alkaline feldspar, anhydrite. The surrounding rock is alteration-developed. Separate pyrite bodies and anhydrite ore bodies are sometimes formed outside the ore body. The ore has a structure such as a lump-shaped, disseminated, disseminated-vein, breccia, striate, stripe-belt shaped. The disseminated ore generally has a $w(\text{TFe})$ of 17% ~ 30%. The lump ore generally has a $w(\text{TFe})$ of 35% ~ 57%, $w(\text{P})$ of 0.1% ~ 1.34%, $w(\text{S})$ of 0.03% ~ 8% or higher, $w(\text{V}_2\text{O}_5)$ of 0.1% ~ 0.3%. Example of a deposit: Meishan Iron Mine.

C.1.3.2 Iron deposits associated with marine volcano-intrusion activities

The deposit is produced near the submarine volcanic eruption center in the trench fold belt. The ore body is formed in a set of volcanic clastic-carbonate-lava (spilite and keratophyre) construction. The ore body is layered, bedded, phacoidal, and a few are vein-shaped and capsule-shaped. They often appear in groups. The length of a single ore body is extended by several tens of meters to more than a kilometer; the thickness is several meters to several tens of meters, up to one hundred meters; the depth is one hundred meters or hundreds of meters, up to several kilometers. Ore bodies are generally flat, whilst the occurrence of small and medium-sized ore bodies is sometimes complex. The ore structure is the same as the mineral deposit related to the continental volcanic-intrusion activity. Meanwhile it has an almond-shaped structure and a directional arrangement. The metal minerals in the ore are mainly magnetite and hematite; there are also martite, siderite, sulfide. The gangue minerals are quartz, albite, sericite, iron chlorite. The iron content of ore is similar to that of the iron ore deposit of continental volcanic-intrusion activity; meanwhile it contains Cu and Co. Most iron ore deposits have higher iron grades and easier to process. However, some mines contain a certain amount of siderite, pyrite, ferrosilite, which affects the ore processing effect. The S, P, V_2O_5 , Cu, Co, etc. as associated with the ore can be recovered comprehensively. Example of a deposit: Dahongshan Iron Mine.

C.1.4 Sedimentary iron deposit

C.1.4.1 Shallow marine sedimentary iron deposit

C.1.4.1.1 Sinian sedimentary hematite and siderite deposits: It is produced in the Sinian system. The bottom of the ore layer is fine sandstone or sandy shale. The roof is black shale sandwiched thin sandstone. It generally has three or four layers of ore. The single layer's thickness is 0.7 m ~ 2 m. The type of ore

ore body extends by several hundred meters to several kilometers; very few can reach more than ten kilometers. The depth extends hundreds of meters to more than a kilometer. The form of the ore body is simple, mostly stratified and bedded. The occurrence is basically consistent with the surrounding rock. In the favorable part of the lean ore layer, sometimes rich ore is found. The individual rich ore bodies are only more than 100 meters along the strike, but the depth can reach more than 1000 meters. Ores and minerals are generally dominated by magnetite; a few mines have more hematite and martite. The ore generally contains a small amount of iron carbonate and iron silicate. Some mines have a high content. The gangue minerals are quartz, chlorite, magnesia amphibole, iron-aluminum garnet, biotite, carbonate minerals, etc. It generally contains a small amount of pyrite. Most of ore has a stripe-belt construction as well as granoblastic and lepidoblastic structure. The ore of most mines has $w(\text{TFe})$ of 20% ~ 40%, $w(\text{SiO}_2)$ of 40% ~ 50%. It generally requires dressing. A few mining areas produce rich ore; the $w(\text{TFe})$ is 50% ~ 60%; it has low content in sulfur and phosphorus. It is suitable for direct smelting. Example of a deposit: Anshan Iron Mine.

C.1.5.2 Metamorphic carbonate type iron ore

Iron ore is produced in various rock formations such as phyllite, marble, dolomitic marble, slate or its contact surface, which is characterized by large changes in ore body's thickness and large proportion of rich ore. The ore body is stratified, bedded, lenticular or irregular. Ore minerals include hematite, siderite, magnetite, limonite. The gangue minerals are quartz, sericite, chlorite, carbonate. The ore structure is dominated by blocks, followed by oolitic and strip-belt shaped. Example of a deposit: Dalizi Iron Mine.

C.1.6 Weathered leaching type iron deposit

This type of deposit is made up of various types of primary iron ore, sulfide deposits, other iron-bearing rocks through weathering and leaching. It is also known as weathering crust deposits.

This type of deposit is characterized by a wide distribution of "iron caps". The form of the ore body is affected by topography and structure. It is irregular or lenticular. The scale is generally small. There are also large and medium-sized deposits. The ore is dominated by loose porous limonite. The gangue is quartz, carbonate, clay mineral, and the like. The ore has a lump, honeycomb, grape-like or earthy structure. The ore has a $w(\text{TFe})$ of 35% ~ 60%. Most mineral deposits contain impurities such as Pb, Zn, Cu, As, Co, Ni, S, Mn, W, Bi depending on the different composition of the primary ore (rock). Ore is difficult to dress. There are certain limitations in industrial utilization. It is mostly used as a blending mineral. Example of a deposit: Dabaoshan Iron Mine.

C.1.7 Other types of iron deposits

Lower Nantuo Formation (Datangpo Formation, Xiangmang Formation), the Upper Dianshantuo Formation; Ordovician Middle Modaoxi Formation, Upper Wufeng Formation; Devonian Upper Lujiang Formation, Wuzhishan Formation; Carboniferous Lower Datangjie Aksake Formation, Middle Huanglong Group; Permian Lower Gufeng Formation, Upper Longtan Formation; Triassic Lower Bocigou Formation and the Beisui Formation, Middle Damao Formation, Upper Songgui Formation. According to the characteristics of ore-bearing rock series and manganese deposits, it is divided into five sub-categories.

- a) Manganese carbonate deposits produced in siliceous rocks, argillaceous limestones, siliceous limestones: It is distributed in basins or troughs. The rock-containing ore series are characterized by impure carbonate rich in siliceous and muddy materials, as well as the occurrence of siliceous rock segment or interlayer. The manganese ore layer is mainly produced in the argillaceous and siliceous limestone section which contains the ore-bearing rock series, which is stratified, bedded, phacoidal. It has a length of hundreds of meters to several kilometers. It has a thickness of one to several meters. The ore has mud crystal structure, in tuberculous, bean-shaped, micro-layered construction. The ore type is rhodochrosite type, calcium rhodochrosite-manganese calcite type, manganese calcite type. Some deposits have silicate-rhodochrosite ore type of chromium in local area. The gangue minerals are mainly quartz, chalcedony, calcite. Most of them are acidic ores. The secondary oxidation zone is developed in the shallow part of the ore. The scale of the deposit is mostly medium and large. Examples of deposits: Xialei Manganese Mine, Longtou Manganese Mine, Datong Manganese Mine.
- b) Manganese carbonate deposits produced in black rock series: The ore-bearing rock series or ore-bearing rock segments are black carbonaceous shale, clay rock. It has horizontal bedding or lineage. The ore bodies are stratified, bedded, phacoidal. It has a length from hundreds to several kilometers. It has a thickness from one to several meters. The ore has mud crystal structure, spheroid structure, a small amount of oolitic structure. It is in lump and stripe-belt construction. The most common ore type is rhodochrosite type, followed by calcium rhodochrosite-manganese calcite type, manganese calcite type. The gangue minerals are mainly quartz, calcite, clay minerals, often accompanied by star-shaped pyrite. It is mainly acidic ore. The near-surface parts develop to varying degrees of secondary oxidation zone. The scale of the deposit is mostly large and medium. Typical deposits include Xiangtan Manganese Mine, Minle Manganese Mine, Songtao Manganese Mine, Tongluojing Manganese Mine, Gaoyan Manganese Mine.
- c) Manganese oxide and manganese carbonate deposits produced in fine clastic rocks: The ore-bearing rock series are variegated silty shale; it is commonly sandwiched with argillaceous limestone and limestone. The

phyllite and green schist. The scale of the deposit is small and medium-sized. Examples of deposits: Lijiaying Manganese Mine, Longtiangou Manganese Mine.

C.2.2.2 Alabandite and manganese carbonate deposits produced in thermal metamorphic or regional metamorphic rock series: It is formed by contact metamorphism or other metamorphism of marine sedimentary deposits. The ore is converted to alabandite-rhodochrosite type or alabandite-manganese dolomite type ore. It has crystalloblastic and spheroidal structure, in stripe-belt shaped construction. It also has a small amount of manganese silicate. The gangue minerals have a small amount of metamorphic silicate minerals, besides quartz, calcite, dolomite. The surrounding rock belongs to slate or green schist. The scale of the deposit is medium. Examples of deposits: Tangganshan Manganese Mine, Tiantaishan Manganese Mine.

C.2.3 Strata-bound lead-zinc-iron-manganese deposit

The deposits are often produced in some relatively fixed layers. They are obviously affected by the later transformation. The ore's composition is complex, with various elements such as iron, lead, zinc. Most of the ore bodies are phacoidal-occurred. The occurrence is similar to the surrounding rock, but not fully integrated. The surrounding rock alteration has dolomitization and iron-manganese carbonation. The primary ore has galena-rhodochrosite type, alabandite-magnetite type, sphalerite-rhodochrosite type, which are in granular, spherulitic, lump, disseminated, streak construction. After secondary oxidation, manganese is significantly enriched; there are manganese ore of pyrolusite-psilomelane type as well as ferromanganese ore of pyrolusite, psilomelane-limonite. The lead-zinc minerals contain cerussite, lead-vanadium, etc., in the semi-oxidization zone; it contains category-1 minerals such as lead-psilomelane and chalcophanite in the oxidization zone. The scale of the deposit is large, medium, small. Examples of deposits: Houjiangqiao Manganese Mine, Mnaoshan Manganese Mine.

C.2.4 Weathered manganese deposit

C.2.4.1 Manganese cap deposit depositing manganese-bearing rock formation: It is a primary sedimentary chromium-bearing manganese rock layer, which is formed by secondary enrichment to form an industrial-value deposit. The ore body maintains the original manganese-bearing rock formation. It is relatively long along the strike. The depth along inclined direction is controlled by the development depth of the oxidization zone, ranging from several meters to tens of meters, individually hundreds of meters. When the manganese-bearing rock formation is flat and most of it is present in the oxidation zone, the ore body has a large extension. The ore is mainly composed of various secondary manganese oxides and hydroxides, with secondary structure and construction. The scale of the deposit is mostly small and medium-sized. Examples of

The deposit is produced in a basic-ultrabasic complex with stratified features and rhythmic structures. It is formed by segregation in the early stage of magma. The ore body is often distributed in the ultrabasic facies such as orthopyroxenite, augite-peridotite, dunite. The ore body is stratified and produced in parallel with multiple layers. The thickness of a single layer is several tens of centimeters to several meters. The extension along strike direction and lateral extension are very stable. The scale of the deposit is huge; it is the most important chrome ore resource in the world. Most of the ore is fine-grained dense-dense-disseminated; the grade is medium; the $w(\text{Cr}_2\text{O}_3) / w(\text{FeO})$ is generally less than 2. Among these deposits are Bush Verde in South Africa, Great Dyke in Zimbabwe, Stillwater in the United States, Kemi in Finland. There are no examples of industrial deposits of this type in China.

C.3.2 Late magmatic chrome deposits

C.3.2.1 A chrome deposit produced in a dunite-clinopyroxenite rock mass dominated by dunite. Most of the ore body presents in the coarse-grained - pegmatitic dunite. It has a gradual transition relationship with the surrounding rock. Its boundary needs to be delineated by chemical methods. The scale of the ore body is generally small, which often consists of mineral wool, mineral bar, mineral nests. The ore is mostly fine-grain sparse - medium-disseminated, dominated by net-ring, stripe, variegated, breccia construction. Locally, there are tumor-like, bean-like, filter-strip constructions. The mineral composition of ore is consistent with the surrounding rock except for the high content of picotite. The ore has the $w(\text{Cr}_2\text{O}_3)$ of generally 5% ~ 20% and the $w(\text{Cr}_2\text{O}_3) / w(\text{FeO})$ of less than 2. The ore-forming picotite is consistent with the epitaxial picotite, most of which is high-iron chromite or aluminum-high-iron chromite. The resources/reserves of such deposits account for a certain proportion of chrome ore resources/reserves in China, but most of them are lean ore, which needs to be beneficiated for industrial utilization. Examples of deposits: Gaositai Chrome Mine, Pingdingshan Chrome Mine, Fangmayu Chrome Mine, Maojiachang Chrome Mine, Songshugou Chrome Mine.

C.3.2.2 A chrome deposit produced in a dunite-augite-peridotite magnesian rock body dominated by augite-peridotite. Most of the ore body presents in the augite-peridotite facies or in the dunite heterogeneous body near the contact zone with the facies and the dunite. It is often distributed in belts and groups in a segmented and concentrated manner. The direct surrounding rocks of the ore bodies are mostly dunite, some of them are augite-peridotite, few are harzburgite. Some ore bodies penetrate into the surrounding rock of the rock mass. The boundaries between the ore body and the surrounding rock are clear. The contact lines are mostly straight lines and broken lines. The ore body has a variety of occurrences and complex forms. It is mostly irregular lenticular, vein-shaped, phacoidal, capsule-shaped, columnar and so on. The outer edge of the ore body often has an alteration fading zone or a chlorite shell of several centimeters to tens of centimeters wide. The ore is mainly composed of

Appendix D

(Informative)

Requirements for control level of exploration

D.1 Type of exploration

D.1.1 Main geological basis for determining the type of exploration

D.1.1.1 Scale of ore body

D.1.1.1.1 Large scale: The length of the iron ore and manganese ore bodies along the strike is more than 1000 m. The extension depth along the tendency is more than 500 m. The surface weathering type iron and manganese ore bodies have a continuous spread area of more than 1.0 km². The chrome ore body has a length of more than 500 m along the strike and an extension depth of more than 200 m along the tendency.

D.1.1.1.2 Medium scale: The iron ore and manganese ore body have a length along the strike of 500 m ~ 1000 m and an extension depth along the tendency of 200 m ~ 500 m. The surface weathering type iron and manganese ore body have a continuous spread area of 0.1 km² ~ 1.0 km². The chrome ore body has a length of 200 m ~ 500 m along the strike and a depth of 100 m ~ 200 m along the tendency.

D.1.1.1.3 Small scale: The iron ore and manganese ore body have a length along the strike of less than 500 m and an extension depth along the tendency of less than 200 m. The surface weathering type iron and manganese ore body have a continuous spread area of less than 0.1 km². The chrome ore body has a length of less than 200 m along the strike and a depth of less than 100 m along the tendency.

D.1.1.2 Shape complexity of ore body

D.1.1.2.1 Simple: The ore body is produced in stratified or bedded. The branching compound is less. The stone-inclusion is rare. The thickness variation is small (coefficient of thickness change $V_m < 50\%$).

D.1.1.2.2 Moderate: The ore body is mostly produced in a bedded, veined or large phacoidal shaped, with stone inclusions. The expansion, contraction, branching compound are common. The thickness varies moderately (coefficient of thickness change $V_m = 50\% \sim 100\%$).

D.1.1.2.3 Complex: The ore body is intermittently produced in the form of

Huangbaiyu mine section), Pangjiapu Iron Mine (10-36 line section), Zunyi Manganese Mine (south wing ore body). The type-II exploration is medium; the scale of ore body is moderate; the change of ore body shape and construction is moderate; the useful components of the ore are relatively uniformly distributed. Examples of deposits: Meishan Iron Mine, Shilu Iron Mine, Baiyun Obo Iron Mine (main ore body, east ore body), Longtou Manganese Mine, Dounan Manganese Mine, Robusha Chrome Mine (No.31 main ore body). The type-III exploration is complex type; the scale of the ore body is small; the change of ore body shape and construction is complex; the distribution of useful components of the ore is nonuniform. Examples of deposits: Daye Iron Mine, Fenghuangshan Iron Mine, Dumiao Iron Mine, Dalizi Iron Mine, Bayi Manganese Mine, Xiangtan Manganese Mine, Wafangzi Manganese Mine, Hegenshan Chrome Mine, Dongqiao Chrome Mine, Jingyu Chrome Mine, etc.

D.1.2.2 Determination of exploration type

The type of exploration shall be determined according to the principle of pursuing the best benefit, the principle of starting from reality, the principle of focusing main ore body, the principle of three divisions of types and allowing transition, the principle of verification and timely revision in practice. The principle of starting from reality is crucial in the determination of the type of exploration. Because the geological changes of each deposit are often different, even the different ore bodies or sections of the same deposit have different degrees of change. In most cases, the changes in the various geological variables that affect the type of exploration do not necessarily develop in the same direction, so that multiple types of combinations occur. Therefore, the type of exploration must be determined from the actual situation; use the variable which most significantly increases the difficulty of exploration as the main basis of determination. Tables D.1 and D.2 of this Appendix are examples of exploration of Panzhihua Iron Mine and Xiangtan Manganese Mine. Although the scale of the ore body is large, the exploration-mining data of the two mines indicate that the difficulty of exploration is increased due to the damage of construction after ore formation, so it cannot be determined as the type-I exploration, but determined as the type-II exploration (Panzhihua Iron Mine) and the type-III exploration (Xiangtan Manganese Mine), respectively. Taking Xialei Manganese Mine as another example, the change characteristics and complexity of each segment are not all the same, wherein the ore body's output within the 0 ~ 35a exploration boundary is relatively regular, so it is determined as the type-I exploration; the change of ore body within the 3a ~ 34a exploration boundary is moderate, so it is determined as the type-II exploration; the segment between the type-I exploration and the type-II exploration (mainly within the 15 ~ 35a boundary) changes complexly, there are many faults, the ore body is seriously cut, it belongs to complex construction, so it is determined as the type-III exploration. It can be seen that for the determination of the type of exploration, it is necessary to be based on actual situation and flexibly use

Appendix E

(Informative)

Estimate of mineral resources/reserve

E.1 Industry index of deposit

E.1.1 Main content

E.1.1.1 Quality indicators of ore

E.1.1.1.1 Boundary grade: The minimum criteria for the content of useful components in a single sample of a delineated ore body. It is the boundary grade between ore and waste rock (including non-mineral stone-inclusions).

E.1.1.1.2 Minimum industrial grade: The minimum average grade requirement for a single ore-layer sample in a single project, also known as the lowest recoverable grade.

E.1.1.1.3 Maximum allowable content of harmful components: In a single engineering sample, the maximum allowable content of components that adversely affect the quality or the processing of the product.

E.1.1.1.4 Comprehensive utilization index of associated useful components: The lowest content criteria of other technically feasible, economically reasonable, comprehensively recoverable, useful components which are associated with the main useful components in the ore body.

E.1.1.2 Technical indicators on mining of deposit

E.1.1.2.1 Minimum recoverable thickness: The minimum true thickness of the ore body (ore layer or vein) available for industrial mining.

E.1.1.2.2 Included-stone's removal thickness: The maximum true thickness value of the non-ore part allowed to be delineated in the ore body because it is hard to remove, also called the maximum allowable true thickness of the included-stone.

E.1.2 General industrial indicators for iron, manganese, chrome deposits

E.1.2.1 Iron ore

E.1.2.1.1 Iron ore for steelmaking is as shown in Table E.1.

the sample's grade, or in the ore-drift engineering, when the sampling spacing is not equal and the sample's grade changes greatly, it shall use the corresponding sample's length or ore body's thickness, sampling distance, and other influence parameters to carry out weighed average against the grade. Otherwise, it shall use the arithmetic mean method for calculation.

E.2.2 Classification of estimation methods

E.2.2.1 Geometric figure method

Divide the spatial form of ore body into simpler geometric forms. Meanwhile calculate the average volumetric mass (weight) of the ore. Use the volume of the volume of the geometric form to multiply density to obtain the estimated result. According to the ore body's occurrence and shape, it can be subdivided into vertical section method, horizontal section method, geological block segment method, etc. The estimation methods of the associated beneficial components are the general estimation method based on the amount of ore of the main mineral, as well as the single mineral analysis estimation method, the concentrate analysis estimation method.

E.2.2.2 Geostatistical method

Based on the theory of regionalized variables, use the variogram as the main tool. During estimation, it shall make full consideration of the spatial variation of ore's grade as well as the spatial distribution characteristics of mineralization intensity, so that the estimation results are consistent with the geological laws of the deposit output, to improve its confidence. This method needs to be based on more sample individuals. At present, the geostatistical method has widely adopted computer technology; there are various input or estimation methods. The commonly used methods are the plane input method, the section input method, the polygon method, the distance weighting method, the Kriging method. Estimated methods for the associated useful components include correlation analysis method, regression analysis method, cooperative Kriging method.

E.2.2.3 SD method

It is a new development of the cross-section method that adopts the computer processing technology. It is an estimation method which is based on the optimal structural geological variables, uses the cross-sectional configuration instead of the spatial configuration as the core, uses the spline function and fractal geometry as the tool. It is applicable to different ore body sizes, occurrences, different exploration stages of various deposit types. It can also make an accuracy assessment of the estimation results.

Appendix F

(Informative)

Glossary

F.1 Total iron (TFe)

The total content of iron elements determined by laboratory analysis of rock ore samples. Total iron is the main technical indicator for evaluating the quality of iron ore.

F.2 Magnetic iron (mFe)

It generally refers to iron in ferromagnetic iron minerals. The content can be determined based on the phase analysis results of iron ore. Magnetite, titanomagnetite, semi-martite are all strong ferromagnetic iron minerals of industrial value. Magnetic separation may be performed in a magnetic field which has a strength of $(6.4 \times 10^4) \sim (8.0 \times 10^4)$ A/m. Although pyrrhotite has strong magnetic properties, it is not used as a magnetic iron mineral with industrial value in iron ore deposits, because of its high sulfur content. In geological exploration, the percentage of magnetic iron in iron ore to the total iron is called the magnetic iron occupancy, which is the basis for evaluating the industrial value of iron ore and for dividing the industrial type of ore.

F.3 Iron sulfide (sfFe)

It refers to iron in iron-bearing sulfides as determined by chemical phase analysis of iron ore, including iron in minerals such as pyrite, marcasite, arsenopyrite, pyrrhotite.

F.4 Iron carbonate (cFe)

It refers to iron in iron-bearing carbonate minerals as determined by chemical phase analysis of iron ore, including iron in minerals such as siderite and ankerite.

In the siderite (FeCO_3), $w(\text{FeO})$ is 62.1%, $w(\text{CO}_2)$ is 37.9%, CO_2 is lost after roasting, so the FeO content is relatively increased. Therefore, when evaluating the siderite deposit, its industrial index can be slightly lower than that of magnetite and hematite. Ankerite has low iron content and belongs to the ore

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